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APPLICATION FOR

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FOR

# REMOTE GAS MOLECULE DETECTOR

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## BACKGROUND OF THE INVENTION

### 1. Technical Field:

The present invention relates to a gas molecule detector. More specifically the invention relates to a laser device for detecting the presence of alcohol molecules from a distance. The device is controlled by a computer system.

### 2. Description of the Related Art:

The colors of an object typically arise because materials selectively absorb light of certain frequency, while scattering or transmitting light of other frequencies. For example an object is red (wavelength range from 6300 and 6800 Å) if it absorbs all visible frequencies except those our eyes perceive to be "red." Thus, we see the scattered wavelength range from 6300 and 6800 Å from that object.

Similarly, gas molecules absorb at different frequencies. A predefined range of wavelength propagating through gas molecules are absorbed at the resonance frequencies of the atoms or molecules, so that one observes gaps in the wavelength distribution of the emerging wavelengths. Absorption lines of a gas molecule have its own intensity and spectral position.

For example, absorption spectrum of simple molecule gas consists of narrow, isolated spectral lines. Alcohol (ethanol) like other complex organic molecule has spectrum that

consists of many overlapping lines. Alcohol molecule has rather broad spectra about 100 times broader than isolated spectral line of a simple molecule. Selecting an alcohol spectrum for detecting the presence of its molecule can be complicate. The strongest and sharpest feature of ethanol absorption spectrum in near infrared range (1.387 – 1.414 μm) is Q-branch with maximum from 1.3924 – 1.3935 μm. On the other hand, the high intensity of absorption lines exists in mid infrared range (3 – 10 μm). In the present invention, the spectrum near 1.392 μm is preferred over mid infrared range because of the following principal:

1. This spectral range is not hazardous for eyes if power of light sources is not more than 1 mW.
2. Glass windows are transparent in this range.

Traditionally, gas molecule detectors utilize infrared spectroscopy to detect the specified gas including alcohol. This type of detection requires complicated optical filters. The accuracy of detection depends on the sensitivity of these filters. Filter may detect more than one type of gas molecules where interference is highly probable.

## SUMMARY OF THE INVENTION

The present invention provides for a more sensitive detection of gas molecules without the use of optical filters by using laser technology, thereby eliminating interference from other gas molecules.

An embodiment of the present invention utilized diode laser ("DL") for alcohol detection because the radiation bandwidth is $10^{-3}$ $cm^{-1}$. In laser diode, radiation is produced by the recombination of electrons and holes at a pn junction (semiconductor). A laser diode is small in size like other semiconductor devices. Its output can be modulated by varying the current.

Diode lasers usually do not employ mirrors for feedback. This is because the refractive index is large enough to give considerable reflection at the semiconductor/air interface. Diode laser allows for fast scanning of the radiation frequency, so measurements are produced simultaneously in a predetermined wavelength range. It allows accounting of specific features of alcohol absorption band, that is important for selective measurements. Special improvements were made in the alcohol detector for subtracting of humidity variations, because water vapor absorption in used wavelength range is rather high. Special improvements were made in present invention for subtracting of various disturbances due to accidental sun illumination, vehicle window curvature and dirt on their surfaces, optomechanic vibrations. With the employment of diode laser, the improved alcohol detector is low cost and small and compact.

## BRIEF DESCRIPTION OF THE DRAWINGS

**Figure 1** is a block diagram of an alcohol detector of according to an embodiment of the present invention.

**Figure 2** is a block diagram of an alcohol detector system according to an embodiment of the present invention.

**Figure 3** is a block diagram of a computer system in accordance with an embodiment of the present invention.

**Figure 4** is a pictorial representation of an alcohol detector controller in accordance with an embodiment of the present invention.

**Figure 5** is a pictorial representation of interface module in accordance with an embodiment of the invention.

**Figure 5(a)** is a DL current supply in accordance with an embodiment of the present invention.

**Figure 5(b)** is a resistance-voltage transformer in accordance with an embodiment of the present invention.

**Figure 5(c)** is a peltier supply in accordance with an embodiment of the present invention.

**Figure 6** is a pictorial representation of a photodetector transformer/amplifier unit in accordance with an embodiment of the invention.

**Figure 7** is a block diagram of software in accordance with an embodiment of the invention.

**Figure 8** is a flowchart of signal processing in accordance with an embodiment of the invention.

**Figure 8(a)** is a graph of DL current corresponding to point number in accordance with an embodiment of the present invention.

**Figure 8(b)** is a graph of [DL current corresponding to point number] in accordance with an embodiment of the present invention.

**Figure 9** is a flowchart for calculation of alcohol concentration in accordance with an embodiment of the present invention.

**Figure 9(a)** is a graph of water and alcohol absorption factors corresponding to the wavelength in accordance with an embodiment of the present invention.

**Figure 10** is a flowchart for DL temperature stabilization in accordance with an embodiment of the present invention.

## DETAILED DESCRIPTION

The description of the preferred embodiment of the present invention has been presented for purposes of illustration and description, but is not intended to be exhaustive or limited to the invention in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art. The embodiment was chosen and described in order to best explain the principles of the invention the practical application to enable others of ordinary skill in the art to understand the invention for various embodiments with various modifications as are suited to the particular use contemplated.

With reference now to the figures and in particular with reference to **Figure 1**, a pictorial representation of alcohol detector **100** in accordance with an embodiment of the present invention is illustrated. Alcohol detector **100** involves diode laser ("DL") **101** assembled with peltier element **120** and thermistor **121,** a temperature sensitive resistor. Diode laser **101** radiating power is proportional to transformed DL current **116**. Diode laser **101** wavelength depends on the temperature of the diode laser **101** from 1.3906 um at 0°C to 1.3933 um at 40°C um. Peltier element **120** and thermistor **121** assist in adjusting and stabilizing the temperature of diode laser **101** such that the emitted wavelength stays near alcohol absorption band at 1.392 um. Initially, thermistor **121** sets the temperature for diode laser **101** with the raw resistance voltage **112**. Peltier element **120** controls the temperature either by removing the heat by pumping heat away from the chamber adjacent to a device or adding heat to that chamber. In this case, the greater,

the transformed pump current **113**, the more heat is removed from the chamber adjacent to diode laser **101**, thereby cooling it. In a preferred embodiment of the present invention, such assembly of diode laser, peltier element, and thermistor is commercially available from Sensors Unlimited, Inc. with part number, SU1393-DFB-TE. Moreover, peltier element **120** and thermistor **121** can be substituted by other temperature stabilizing components. Diode laser **101**, peltier element **120** and thermistor **121** are housed inside thermostatic enclosure **102**. Thermostatic enclosure **102** helps to keep the temperature of the assembly constant without the effect of the changing temperature of the outside environment. Outside of thermostatic enclosure **102**, the alcohol detector further includes optical components for analytical optical scheme and for reference optical scheme.

In the analytical optical scheme, diode laser **102** radiation is channeled into a single mode fiber **103** of about two meters long. Single mode fiber **103** narrows or diminishes the concentration of radiation in which the inhomogenity of DL radiation is 0.3%. At various pumping current values, radiation is generated by different regions of the diode laser active area with different directional patterns and radiating power. As a result, the cumulative dependence of radiating power on pumping current varies for different angles of DL radiation pattern. In the used DL radiation pulse mode when radiation frequency is scanned by current within a pulse, the pulse shape of a photoreceiver signal varies depending on a part of DL radiation pattern falling on a photoreceiver platform. It turned out that the homogeneous laser radiation pattern can be most effectively obtained using a single mode optical fiber with 7 um diameter of central

part. DL radiation transmitted through the fiber ~ 2m long results in the highly homogeneous radiation pattern at the fibre exit. The output of the single mode fiber **103** is diverged at a 10° angle obeying the Gaussian law.

Then the radiation is passed through objective **104** to be adjusted by refraction in order to fully illuminates the cube reflector **105**. Between objective **104** and reflector **105**, the radiation may have pass through an enclosure, for example, a moving vehicle on the road with alcohol molecules within the enclosure. The absorption of the alcohol molecules occurs for the first time. In a preferred embodiment of the present invention, alcohol molecules may be detected here. The reflected radiation fully illuminates spherical mirror **106** having a 6.5 cm diameter, which is positioned behind objective **104**. The optical path between reflector **105** and spherical mirror **106** undergoes a second absorption of the alcohol molecules inside the enclosure. Because radiation passes through the enclosure twice, the absorption of the alcohol molecules amplifies. Spherical mirror **106** focuses the absorbed radiation on the sensing area of analytical photodetector **107**. Then, photodetector **107** generates raw analytical PD1 signal **114**.

In the reference optical scheme, splitter **108** generates a reference radiation. Splitter **108** is positioned after objective **104**. The reference radiation passes through reference cell **109** having a predetermined concentration of water molecules. Next, the reference radiation is reflected by spherical mirror **110** to pass through the reference cell **109** again before reaching the sensing area of reference photodetector **111**. Reference photodetector **111** generates raw reference PD2 signal **115**. In a preferred embodiment,

radiation is ready for detection when the reference radiation passes once through reference cell **109.** Photodetectors **107** and **111** of the Alcohol detector are Germanium photodiodes with sensing area near 2 $mm^2$ and Noise Equivalent Power (NEP) $10^{-11}$ $W/Hz^{1/2}$.

Those of ordinary skill in the art will appreciate that the detector is capable of detecting alcohol or other gas molecules. This detailed description specifically describes alcohol molecules, which may be substituted by other detectable gas molecules having distinct absorption band. The diode laser may emit radiation according to the gas molecule absorption band. The reference cell's content may differ. The depicted example is not meant to imply molecule limitation with respect to the present invention.

Referring now to **Figure 2**, a block diagram of an alcohol detector system is shown in accordance with a preferred embodiment of the present invention. Alcohol detector system **200** includes computer system **201**, alcohol detector **202**, interface module **203**, photodetector transformer amplifier unit **204**, and software **205**. Software **205** initializes and synchronizes alcohol detector system **200**. It also provides for alcohol detector system signal processing and storing and analyzing data. Computer system **201** provides processing and control to alcohol detector system **200**. There are five signals communicating between computer system **201** and alcohol detector **202**. These signals must pass through either interface module **203** or photodetector transformer amplifier unit **204**. Computer system **201** receives three data inputs; amplified PD1 signal **210** and amplified PD2 signal **211** from photodetector transformer amplifier unit **204** and

transformed resistance/voltage signal **212** from interface module **203**. These inputs are differential lines. Computer system **201** transmits two outputs, raw diode laser current **213** and raw pump current **214** to interface module **203**.

On the other end of interface module **203** and photodetector transformer amplifier unit **204**, alcohol detector **202** transmits three data signals, raw PD1 signal **220** and raw PD2 signal **221** to photodetector transformer amplifier unit **204** and raw resistance voltage **222** from interface module **203**. Alcohol detector **202** receives two inputs, transformed tunable current **224** and transformed Pump current to interface module **223.**

Referring now to **Figure 3**, a block diagram of a computer system **201** is shown in accordance with a preferred embodiment of the present invention. Computer system **201** may employ a single microprocessor **301**, or in the alternative, multiple microprocessors on the system bus **302**. A storage device is connected to a memory bus **304**. An input/output ("I/O") device may be integrated to the I/O bus **303** as depicted. A storage device includes memory devices such as hard disk drive **306**. I/O device includes an alcohol detector controller **305** for assisting in the control of an alcohol detector. Computer system **201** controls and communicates with the alcohol detector.

Those of ordinary skill in the art will appreciate that the hardware depicted in **Figure 3** may comprise of multiple microprocessors, multiple storage devices, or multiple I/O devices. These devices may vary. For example, other peripheral devices, such as optical disk drives and the like, also may be used in addition to or in place of the

hardware depicted. The depicted example is not meant to imply architectural limitations with respect to the present invention.

Referring now to **Figure 4**, a block diagram of an alcohol detector controller **305** is illustrated. Controller **305** involves three inputs and two analog outputs interfacing the alcohol detector **305** and a computer PCI bus. Controller **305** receives amplified analytical PD1 signal **401** amplified reference PD2 signal **402**. Controller **305** also receives transformed resistance/voltage signal **403**. Transformed resistance/voltage signal **403** is multiplexed with amplified analytical PD1 signal **401** and amplified reference PD2 signal **402**. A multiplexor **410** allows successive connecting of inputs to analog to digital converter ("ADC") **411** with set update rate, which value can't exceed a predetermined sampling frequency, 1.25 MHz. Next, dither **412** may be used for smoothing of bits in ADC **411** output signals. A timer controlled by software serves as clock cycle for alcohol detector controller **305**. It may include a frequency divider that allows for frequency adjustments of output signal generation and data acquisition. A trigger is controlled by the timer. It serves as a synchronizational signal for the signal generation and data acquisition. If this triggering synchronization switches at a common frequency, it creates an operational frequency for the alcohol detector controller **305.**

With regards to controller's outputs, data are stored in buffer memory **413**. A predetermined pulsed signal for DL current pulse is stored in buffer memory **413** for DL current. The data stored in the buffer memory **413** flows to the first digital-to-analog converter ("**DAC1**"). **DAC1** supplies continuous train of raw DL current **404**. Pump

current for the peltier element must be calculated by the computer system. Then pump current data is transferred and stored in buffer memory **413** in which it flows to the second digital-to-analog converter ("**DAC2**"). **DAC2** supplies continuous train of raw pump current **405**. Controller **305** is installed in the computer PCI bus **406** and connected with Interface module and photodetector transformer/amplifier unit. Data exchange between controller **305** and computer through reads and writes of controller's **305** buffer memory **413**. In a preferred embodiment of the present invention, controller **305** is configured from a standard multifunctional NI-DAQ board of the PCI-MIO-16E-1 produced by National Instruments, Inc.

Referring now to **Figure 5**, a pictorial representation of interface module **203** in accordance with an embodiment of the present invention is illustrated. Interface module **203** involves three analog units: DL current supply **510,** resistance - voltage transformer **520**, and peltier current supply **530**. Interface module **203** provides interface for three signals between the alcohol detector **100** and alcohol detector controller **305**. In **Figure 5(a)**, DL current supply **510** amplifies and transforms the pulse of raw DL current **517** into pulses of amplified DL current **518** feeding alcohol detector. It includes three operational amplifiers, **511-513**. Resistance R1 **514** and capacitance C1 **515** define frequency bandwidth. Resistance R2 **516** defines the current/voltage transformation factor. The output operational amplifier $A_2$ **513** and resistor $R_2$ **516** are chosen thermo stable for preventing drift of output parameters.

Two other units of interface module **203**, resistance - voltage transformer **520** and Peltier current supply **530**, are intended for stabilizing and adjusting the diode laser temperature. The temperature of thermistor having good thermal contact with diode laser in alcohol detector **100** is measured in the Resistance/Voltage Transformer unit **520** as depicted in **Figure 5(b)**. Resistance - voltage transformer unit **520** includes two operational amplifiers **521** and **522** and stable current supply **523**. Current supply **523** ensures that a current of 100 uA flows the thermistor $R_t$ **524**. Resistance - voltage transformer unit **520** transforms raw resistance - voltage signal **526** into a voltage value for transformed resistance - voltage signal **525**. Transformed resistance - voltage signal **525** transmits to Controller **305** as one of the inputs, which is later transformed into degree value in the device software.

In **Figure 5(c)**, the raw pump current **531** from alcohol detector controller **100** is transmitted to Peltier current supply **530** of the Interface module **203**. Peltier current supply **530** constitutes a power amplifier for supplying differential voltage for transformed pump current **532**. The unit includes three operational amplifiers, **534-536**, resistance $R_6$ **537** and capacitance $C_2$ **538** restrict frequency bandwidth, resistances $R_7$ **539** and $R_8$ **540** restrict maximum output current for transformed pump current **532**. All units of the Interface module **203** are storage battery-powered; the batteries being very stable sources. Such independent power supply ensures stable operation and high values of a signal to noise ratio.

Referring now to **Figure 6**, a pictorial representation of a photodetector transformer/amplifier unit **204** in accordance with an embodiment of the present invention is illustrated. Photodetector transformer/amplifier unit **204** transforms raw analytical PD1 signal **601** and raw reference PD2 signal **602** respectively into differential amplified analytical PD1 signal **603** and amplified reference PD2 signal **604**. Amplified analytical PD1 signal **603** and amplified reference PD2 signal **604** are inputs of Alcohol Detector Controller **305**. Base scheme of these transformer-amplifiers is shown at **Figure 6**. The first stage of the scheme is typical transimpedance amplifier **A9** where **R9** and **C3** are feedback resistance and capacitance respectively. Amplifier frequency bandwidth is defined by capacitance **C3**, transfer factor at low frequencies is defined by resistance **R9**. Second stage of the scheme is voltage amplifiers **A10** and **A11** for generating differential outputs. Photodetector transformer/amplifier unit **204** is also battery-powered for providing high signal to noise ratio.

Referring now to **Figure 7**, a block diagram of software **205** in accordance with an embodiment of the present invention is illustrated. Software **701** initializes and synchronizes alcohol detector system **200**. It also provides for alcohol detector system computer program instruction for signal processing **702**, diode laser temperature stabilization **703**, calculation of alcohol concentration **704** and other operations are produced in the base part of the program **705**.

Referring now to **Figure 8**, a flowchart of signal processing **702** according to an embodiment of the present invention is illustrated. The software provides instructions for

signal processing for generating the pattern of pulses of DL current (step **801**). The pulse pattern period must in proportionate to the digital to analog converter update rate. The pattern is then stored in the alcohol detection controller's buffer memory (step **802**). The software further provides instructions for applying the pattern to the alcohol detection controller's digital to analog converter (step **803**). In a preferred embodiment of the present invention, the pulse period is 3.6 ms with 0.85 duty factor. Therefore, the pulse is above the threshold current for 3.0 ms, and below the threshold current for 0.6 ms. The DAC's update rate is 500 kHz. Thus, in order to generate a pulse period, the signal processing **702** must generate 1800 points to be store in the buffer memory. Of the 1800 points, 1500 points is for generating current above the threshold level and 300 points for below. A graph of raw DL current with point number is depicted in **Figure 8(a)**.

Current pulse is high frequency square modulated with rather high modulation amplitude. If the controller update rate equals 500 kHz, the modulation period equals 12 us, so each period includes 6 points: three points at higher amplitude, three points at lower amplitude and so on. See **Figure 8(b)**. As a result each pulse is divided in two branches: upper and lower. Each branch in the pulse is of trapezoid form with the same slope. So DL radiation wavelength is swept in each branch in different ranges. For ethanol detection the ranges of scanning diode laser radiation wavelength were chosen the following: 1.39262 um – 1.39284 um for lower branch and 1.39262 um – 1.39274 um for upper branch. The DAC in the alcohol detector controller, transform the pulsed pattern into a continuous raw DL current.

Referring now to **Figure 9**, a flowchart for calculation of alcohol concentration **704** according to an embodiment of the present invention is illustrated. The process for calculating alcohol concentration starts with the receipt of sampled data from the analytical photodetector signal at beginning of the current pulse (step **901**).

Three controller inputs (step **902**): (1) photodetector signal from analytical channel (step **903**), (2) photodetector signal from reference channel (step **904**), (3) signal proportional to thermistor resistance (step **905**), are used in present invention. They are applied to the controller ADC successively, so sampling frequency of each input is three times lower than the controller update rate and equals 166.6 kHz. Pulse duration in photodetector signals includes 500 points, duration between adjacent pulses includes 100 points, and pulse repetition period includes 600 points. Modulation period in the signals is two times more than duration between adjacent points; so even points form one branch (low), odd points form another branch (high).

The first channel contains sampled analytical PD1 signals made up of a train of pulses having 3.6 ms period (step **903**). The software separates the pulses for independent treatment of each pulse (step **906**) according to a period or cycle of a pulse. In step **907**, the value of "zero signal" between two pulses is subtracted from each of the points respectively. "Zero signal" is PD signal when laser is switched off. This signal includes photodetector preamplifier output shift and value connected with illumination of photodetector by other light sources. The value of zero signal is averaged by 100 points between two adjacent pulses. Step **907** lessens interference of photodetector illuminated

by another sources (i.e. light illumination reflected by pieces of glass or car windows). The result from subtracting zero signal is saved as background pulse (step **908**). Next the process calculates the difference between the background pulse and the raw current (step **909**). The independent pulse is further separated into two arrays: (a) an odd array for storing all the odd points; and (b) an even array for storing all the even points (step **910**). Another procedure for lessening interference, in step **911**, is calculating the logarithm of the ratio of respective even point over odd point (e.g. Ln(even/odd)). Logarithm value is proportional to the difference of absorptions at the branches wavelength ranges and would lessen any low-frequency signal interference from mechanical vibration or interfering illumination.

The predetermined Fourier Transform is stored in memory and accessible by the system. Unique features of absorption spectrum of alcohol and water in the range of wavelength scanning are used for their detection. **Figure 9(a)** shows the predetermined absorption lines of alcohol and water at wavelength range around 1.39268 um. The calculated concentration of water (content in the reference cell) and alcohol is distinguished from each other by mutual orthogonalization of the correlated factors of alcohol and water (steps **912** and **913**) e.g. gas molecules to be detected and the content in the reference cell. In a preferred embodiment of the present invention, **X** denotes input processed signal (in this case, it is Ln(even/odd)), **A** denotes alcohol function (difference of alcohol absorption factors in the wavelength ranges corresponding to upper and lower parts of laser radiation), and **W** denotes water function. **X, A,** and **W** are one-dimensional

arrays or vectors. The number of values in these arrays equals to (pulse point number)/2. For our parameters this number is equal to 300. Orthogonalization of **X** with respect to water is:

$$\mathbf{X_w = X - (X*W)*W/(W*W),}$$

where **(a*b)** is scalar product of two vectors. Accordingly orthogonalization with respect to alcohol is:

$$\mathbf{X_a = X - (X*A)*A/(A*A).}$$

The calculation of correlation factors may be produced after orthogonalization. Correlation factor of orthogonalized signal and alcohol function is: a = $(\mathbf{X_w*A})$, this value for water function is: w = $(\mathbf{X_a*W})$ in which a is proportional to ethanol concentration, and w is proportional to water concentration.

Lastly, the concentration of water and alcohol is calculated by correlating the arrays with the predetermined absorption functions of alcohol and water (steps **914** and **915**).

Referring now to **Figure 10**, a flowchart for DL temperature stabilization **703** according to an embodiment of the present invention is illustrated. Initially, the diode laser's temperature is set with the help of the thermistor (step **1001**). First the process receives the transformed resistance/voltage signal (step **1002**) from thermistor. With a predetermined load thermistor calibration function, the thermistor's actual temperature can be calculated (step **1003**). Then with a set predetermined laser temperature and

thermistor's actual temperature, the process calculates the temperature difference (step **1004**). Next, the process calculates the PID (Proportion, Integral, Derivative) value (step **1005**) in order to determine the pump current (step **1006**). Initially, the diode laser and thermistor should have the same temperature until the diode laser generates more heat in which the temperature of the two components differs. As a result, thermistor's temperature is stabilized and not the diode laser. After the initial setting of the temperature, the process switches to line stabilization position (step **1010**) for stabilizing DL temperature. The absorption line position within a recorded pulse is an unbiased criterion of DL true temperature. First, it receives the sampled data from amplified reference PD2 signal (step **1011**). Each pulse is separated from the other (step **1012**) for subtraction from zero signal (step **1013**). The process repeats step **1013** one hundred times (100x) for one hundred pulse period before it takes the average value (step **1014**). Next, with a preferred predetermined laser temperature and the calculated average value, the temperature difference is calculated (step **1015**). Then the PID value must be calculated (step **1016**) before the determination of pump current (step **1017**). The difference between current absorption line position and predetermined one come to the input of PID (Proportion, Integral, Derivative) program module. Value from output of this module is applied to DAC 2 for feeding Peltier element. This value at n step of the

program cycle ($V_n$) is calculated in conformity with formula:

$$V_n = a*P_n + b*I_n + c*D_n$$

where $P_n$ is the difference (see above) at n step of the program cycle, $I_n = \sum_{0}^{n} P_i$,

$$D_n = P_n - P_{n-1}\text{ , a, b, c – factors.}$$

Because Pump current is not constant and must be determined, Pump current is tunable and directly stabilizes DL temperature. The determined Pump current is applied DAC2 on the controller in which the Pump current is made continuous before channeling to the interface module. DL temperature variations directly affect the DL radiation wavelength variation. The stabilization of DL temperature ensures that DL will operate in the stable range near the maximum alcohol absorption band at 1.39268 um.

Although preferred embodiments of the present invention have been described in the foregoing Detailed Description and illustrated in the accompanying drawings for alcohol detection, it will be understood that the invention is not limited to the embodiments disclosed, but is capable of detecting other gas molecules which may require numerous rearrangements, modifications, and substitutions of steps without departing from the spirit of the invention. For example, each gas molecule having distinct absorption band would require a diode laser radiating at or near that band, the photodetector functions at the distinct absorption band, the predetermined DL current may differ in the sampled points and duration, the reference cell may differ in content. etc. Accordingly, the present invention is intended to encompass such rearrangements, modifications, and substitutions of steps as fall within the scope of the appended claims.